Acta Botanica Brasilica - 35(4): 612-620. October-December 2021.
doi: 10.1590/0102-33062020abb0476

Phytoplankton dynamics in a drinking water catchment zone at the Amazon River mouth

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Received: November 13, 2020
Accepted: April 16, 2021

ABSTRACT

Phytoplankton is formed by photosynthesizing microorganisms that act as primary producers in distinct water bodies. These include microalgae and cyanobacteria. It is essential to know the phytoplankton in water catchment areas intended for drinking water treatment once their excessive density may result in problems, such as taste and odor in the water, toxin production, filter clogging, and other damages. This study investigated the phytoplankton dynamics and the environmental factors that may influence phytoplankton density in the drinking water catchment zone of Macapá, a city located on the Amazon River mouth. The sampling was carried out monthly from April/2015 to March/2016. The study reports the first detailed information on the phytoplankton in the study area since previously published studies regarded only cyanobacteria. The species *Limnothrix planctonica* and *Aulacoseira granulata* may substantially influence the water treatment due to their great abundance in the study area, especially in July and November, when their density peaks occur, respectively. Nevertheless, *Aulacoseira granulata* is the primary constituent of the phytoplankton biovolume. This study provides biological and sanitary information to guide public administration towards improving the quality and safety of water supply services, and also to increase the biodiversity knowledge of Amazonian phytoplankton.

Keywords: Amazon River, cyanobacteria, Macapá, microalgae, water supply, water treatment

Introduction

Phytoplankton comprises photosynthetic microorganisms-microalgae and cyanobacteria-adapted to live partly or continuously in open water (Chorus & Bartram 1999; Reynolds 2006). These organisms are responsible for the oxygenation of aquatic ecosystems, where they act as the primary producer of organic carbon (Reynolds 2006).

Phytoplankton populations may increase rapidly (bloom) as a consequence of eutrophication and pollution of the water body. High phytoplankton densities in the water supply impair the water quality since these organisms may cause several problems for drinking water treatment, such as the production of toxins, taste and odor compounds, trihalomethanes, clogging of filters, and reduction of efficiency to produce finished water (Di Bernardo 1995; Chorus & Bartram 1999; Ewerts *et al*. 2013; Oliver & Ribeiro, 2014).

Some species from the cyanobacteria, diatoms, chlorophytes, chrysophytes, rhodophytes, and dinoflagellates

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are known to cause problems to water treatment plants (Watson 2009; Ewerts *et al*. 2013; Niiyama *et al*. 2016). In the case of the production of taste and odor compounds, some of the principal causes that make difficult the source-tracking of these compounds include species misidentification (Watson & Jüttner 2019). Because of these issues, it is essential to know the phytoplankton composition and density to prevent or quickly solve future trouble related to water treatment concerns.

This study was conducted in Macapá, a city located at the Amazon River mouth, whose waters are the primary source of water supply in town. This estuary area has multiple uses like the loading/unloading of cargo and passengers, sports, bathing, fishing, and leisure (Oliveira *et al*. 2019a). Besides that, there is an occasional and diffuse discharge of effluents into the river, which provides nutrients for phytoplankton population growth (Bastos *et al*. 2009).

The purpose of this study is to investigate the phytoplankton composition, density, and biovolume, and the environmental factors that may have an influence on phytoplankton density in the drinking water catchment zone of Macapá. The results intend to guide public administration towards improving the quality and safety of water provision services.

Materials and methods

Study area and sampling procedures

The samples were collected in the city of Macapá, at the Company of Water Supply and Sewage of Amapá (CAESA), at the raw water intake point, which is situated approximately 500 meters from the Amazon River bank (Fig. 1), nearby the city downtown. Macapá is a city located in the Northern Channel of the Amazon River in the State of Amapá, Brazilian Amazonia.

Figure 1. Study area: water intake point for water supply in the municipality of Macapá, State of Amapá.

Sampling occurred monthly from April/2015 to March/2016 during a tidal cycle (13 hours). We collected material for qualitative and quantitative studies of phytoplankton as well as physicochemical analysis of the water.

Environmental variables

The environmental data measured were turbidity, suspended solids, precipitation, insolation, radiation, water temperature, water transparency, dissolved oxygen, nutrients (nitrate, nitrite, ammonia, phosphorus, and phosphate), and pH (Tab. 1).

Qualitative analysis of phytoplankton

We collected the qualitative analysis samples every two hours, using the horizontal and simultaneous dragging of two plankton nets-20µm and 64µm mesh opening. In one day of sampling work, we provided seven samples for each plankton net used. In the laboratory, we took aliquots from the 20µm mesh samples and combined them into a single representative sample; we did the same with the 64µm mesh samples. This technique, known as composite sampling (Brandão *et al*. 2011), allowed the formation of a monthly qualitative sample for each plankton net employed, which reduced the sampling effort and shortened the analysis time. Qualitative samples were preserved with *Transeau's* solution (Bicudo & Menezes 2006).

We identified the taxa under standard light microscopy with the aid of specialized bibliography (Prescott *et al*. 1977; 1982; Anagnostidis & Komárek 1986; 1988; Komárek & Anagnostidis 1999; Godinho 2005; Bicudo & Menezes 2006; Sant'Anna *et al*. 2006; Faustino 2006; Godinho 2009) and recent taxonomic papers describing new genera, examining ten slides for each sample. Richness was calculated as the number of species founded in the slides.

Phytoplankton counting

For phytoplankton counting, we collected samples monthly at the raw water intake during high tide and stored them in a 1L amber glass bottle, preserved with 8mL of Lugol's solution. The quantitative analyzes were performed using the Utermöhl sedimentation method (Utermöhl 1958) in 5 mL Utermöhl chambers, visualized in an inverted microscope under a 400x magnification. After sedimentation, we counted the organisms throughout the whole chamber base. To obtain the phytoplankton density (organisms per milliliter), the number of organisms was multiplied by 0.2 (1/5=one whole base of the chamber divided by the decanted volume 5mL) (APHA 2010; Cetesb 2012). To determine the abundant and dominant species, we used the Lobo & Leighton (1986) criterion, where abundant species are those whose number of individuals is higher than the average value of the total number of individuals per species in a sample. The dominant species are those with ≥50 % of the total number of individuals in the sample.

Average and total biovolume

The average biovolume (μm^3) was determined from measurements of 10 to 30 individuals of each species taking into account the simplest geometric configuration (sphere, cone, cylinder, prism, ellipsoid, spheroid, and cuboid) that best suited for phytoplankton organisms' shapes, disregarding mucilages or arrows (Hillebrand *et al*. 1999). As a means to obtain the total biovolume (μm^3 mL^{-1}), we multiplied the average biovolume of the individuals by their density.

Statistical analysis

A Canonical Correspondence Analysis (CCA) was used to infer the relationship between abiotic variables and phytoplankton species. To perform the CCA, we used data on the relative abundance of phytoplankton. Species with a density of ≤ 10 % of the total density or frequency of occurrence <1/5 of the most common species were excluded to reduce trends caused by rare species. Then, we transformed the biological and environmental data into ln (x + 1) to standardize distribution and reduce the effects of the most abundant species. After that, we selected physical and chemical parameters with the ordistep function of the R 3.4.3 software (R Development Core Team 2017). Subsequently, we calculated the inflation factor (VIF) to exclude multicollinear variables, eliminating the variables with VIF≥ 15 (Oksanen 2012). This selection aimed at removing irrelevant explanatory variables in the analysis, highly correlated factors, and variables with relatively little variation (Ter Braak & Verdonschot 1995).

After the screening above, we performed CCA with four environmental variables (suspended solids, rainfall, ammonia (NH_4), and dissolved oxygen) and the most common phytoplankton species detected in the study.

Results

Environmental aspects

The characterization of the environmental parameters is summarized in Table 2. Throughout the study, the Amazon River turbidity presented an average value of 49.30 NTU (range= 19.80-122 NTU), and suspended solids averaged 52.85 mg.L^{-1} (range= 24.70- 119.20 mg.L^{-1}). The water transparency varied from 12.50 cm (rainy season) to 36.50 cm (dry period).

Regarding monthly precipitation in Macapá city, the wettest months were April 2015 (584.50 mm) and February 2016 (528.20 mm). It is noteworthy that there was no rainfall in September, October, and November 2015 (dry period of the region). The average monthly insolation in Macapá ranged from 3.30 to 9.79 hours, and the months between August-December 2015 presented the highest insolation. Regarding irradiation, on the sampling day, there was a variation between 86.60 to 312.30 W.m^{-2}, with an average of 236.82 W.m^{-2}.

Table 1. Measurement units of the physical and chemical parameters, methods, analysis equipment, and database.

	Parameter	Unit	Method / Equipment / Database
Physical	Turbidity	NTU	Horiba multi-parameter probe
	Suspended solids	mg L^{-1}	Gravimetric analysis (APHA 2012)
	Rainfall	Mm	INMET
	Insolation	Hour	INPE
	Radiation	W m^{-2}	INP
	Water temperature	°C	Horiba multi-parameter probe
	Water transparency	Cm	Secchi Disk
	Dissolved Oxygen (DO)	mg L^{-1}	YSI 550 A DO (Dissolved oxygen meter)
Chemical	Nitrate (NO_3)	mg L^{-1}	Cadmium reduction (APHA 2012)
	Nitrite (NO_2)	mg L^{-1}	Diazotization (APHA 2012)
	Ammonia (NH_3)	mg L^{-1}	Phenate method (APHA 2012)
	Phosphorus (P)	mg L^{-1}	Molybdenum blue (APHA 2012)
	Phosphate ($PO4^{3-}$)	mg L^{-1}	Molybdenum blue (APHA 2012)
	Water pH measurements	-	Orion Star A121 pH meters

Table 2. Minimum, maximum, average and standard deviation values of environmental variables. Turb – Turbidity (NTU); SS – Suspended solids (mg L-1); Rain – Rainfall (mm); Ins – Insolation (hours); Irrad – Irradiation (W m-2); W T – Water Temperature (°C); Transp – Water transparency (cm); DO - Dissolved oxygen; NO3 – Nitrate (mg L-1), NO2 – Nitrite (mg L-1); NH3 – Ammonia (mg L-1); P – Phosphorus (mg L-1); PO43- - Phosphate (mg L-1); pH – Hydrogen potential.

	Turb	SS	Rain	Ins	Irrad	W T	Transp	DO	NO_3	NO_2	NH_3	P	PO_4^{3-}	pH
Minimum	19.80	24.77	0.00	3.30	86.60	28.12	12.50	6.60	0.00	0.02	0.00	0.00	0.00	6.00
Maximum	122.00	119.2	584.50	9.79	312.30	30.27	36.50	7.79	0.93	0.07	0.20	0.12	0.38	7.20
Average	49.30	52.85	213.66	7.05	236.82	29.60	26.21	7.16	0.46	0.04	0.06	0.03	0.08	6.57
Standard Deviation	37.23	33.52	221.87	2.33	76.23	0.66	8.75	0.40	0.38	0.02	0.06	0.03	0.11	0.28

The average water temperature in the Amazon River was 29.6 °C (range= 28.12 -30.27 °C); dissolved oxygen ranged from 6.60 mg.L^{-1} to 7.79 mg L^{-1}; and pH values ranged from 6.0 (slightly acidic) to 7.2 (neutral) (Tab. 2).

Regarding nutrients, nitrate values ranged from 0.08 to 0.93 mg.L^{-1}; nitrite from 0.02 to 0.07 mg.L^{-1}; ammonia from 0.01 to 0.20 mg.L^{-1}; phosphorus from 0.01 to 0.04 mg.L^{-1}; and phosphate from 0.02 to 0.38 mg.L^{-1}.

Qualitative analysis of phytoplankton

Species composition analysis allowed the identification of 180 taxa distributed in six divisions: Cyanobacteria, Chlorophyta, Bacillariophyta, Euglenophyta, Charophyta, and Ochrophyta (Tab. S1 in supplementary material). Charophyta was the most expressive group, presenting the highest richness values (S = 73). Species richness ranged from 59 to 114 taxa over the study period, with April and September 2015 showing the highest richness values, 114 and 110, respectively (Fig. 2).

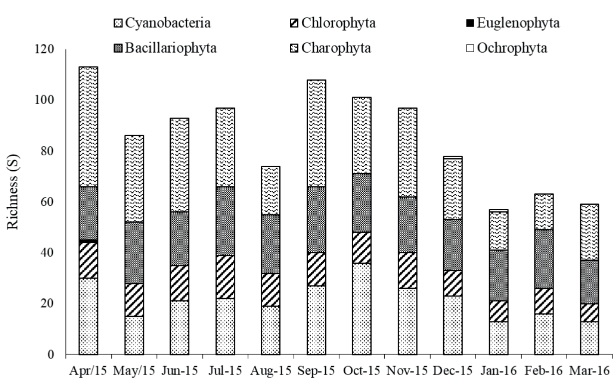

Figure 2. Richness by taxonomic division.

Phytoplankton counting

We identified forty-four taxa in the counting samples, belonging to Bacillariophyta, Charophyta, Chlorophyta, Cyanobacteria, and Euglenophyta. Diatoms presented higher density throughout the study except in July when Cyanobacteria were the group with the highest density values.

The months of highest phytoplankton density were July (72.6 org. mL^{-1}) and November 2015 (117 org. mL^{-1}), when there were peaks of cyanobacteria and diatoms, respectively. In July 2015, the Cyanobacteria density was 44.4 org. mL^{-1} (61.2 % of total period density), and in November 2015, the Bacillariophyta density was 109.6 org.mL^{-1} (93.7 % of total month density) (Fig. 3).

Figure 4 shows a comparison between the total phytoplankton density and that of *Aulacoseira granulata* and *Limnothrix planctonica*. The organisms with the highest density values were: *A. granulata* (Heterokontophyta) and *L. planctonica* (Cyanophyta) (Fig. 5). The high density of these two species resulted in the dominance alternation of Bacillariophyta and Cyanobacteria.

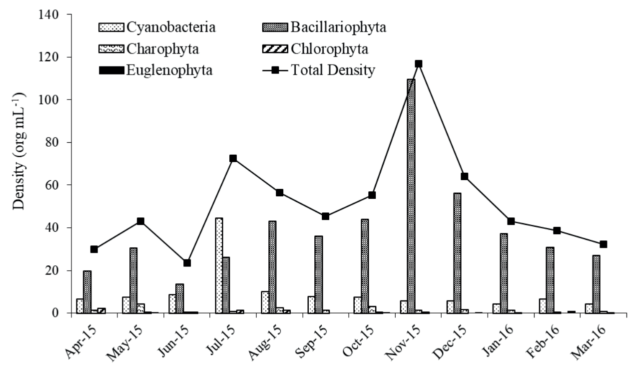

Figure 3. Phytoplankton density by taxonomic division in the Amazon River from April 2015 to March 2016.

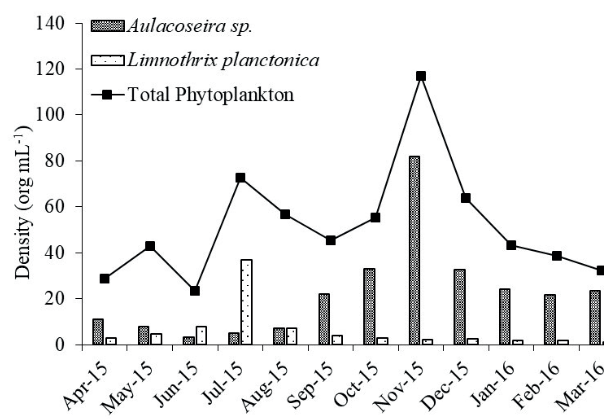

Figure 4. Comparison between the total phytoplankton density and that of the most abundant species.

Aulacoseira granulata and *Limnothrix planctonica* were dominant species, while *Alkalinema pantanalense*, *Leptolyngbya* sp., *L. planctonica*, *Closterium acutum*, *Ulnaria* sp., *Placoneis* sp., *A. granulata* e *Actinocyclus* sp. were considered abundant (Figs. 5 and 6).

Determination of total and average biovolume

Bacillariophyta species showed the highest biovolume values (Tab. 3), suggesting that the phytoplankton in the study area is essentially formed by diatoms. Thus, whereas the density results indicated significant participation of Cyanobacteria, the biovolume determination revealed that Bacillariophyta had a greater number of large species than the other groups.

The monthly phytoplankton biovolume ranged from 53075.9 µm³ mL^{-1} in June/2015 to 774438.6 µm³ mL^{-1} in November/2015. This peak was influenced by the species *Aulacoseira granulata* (Bacillariophyta). The pattern of phytoplankton density results was different from the biovolume. For density, two months were remarkable (July/15 and November/15) with emphasis on the densities of *Limnothrix planctonica* and *A. granulata*; however, regarding biovolume, *A. granulata* stands out for its high dimensions. In this sense, diatoms constitute the phytoplankton in the

Figure 5. Abundant and dominant species: (**A**) *Aulacoseira granulata*, (**B**) *Alkalinema pantanalense*, (**C**) *Limnothrix planctonica*, (**D**) *Leptolyngbya* sp., (**E**) *Placoneis* sp., (**F**) *Actinocyclus* sp., (**G**) *Closterium acutum*, and (**H**) *Ulnaria* sp.

study area, especially *Aulacoseira granulata* (Fig. 5A). Figure 7 shows the significant participation of this species in total monthly biovolume.

Influence of environmental factors on phytoplankton

To perform canonical correspondence analysis (CCA), a previous statistical analysis (forward selection) chose the environmental variables that had more influence on the abundance of phytoplankton from a matrix of 14 environmental variables (Tab. 2): suspended solids, rainfall, ammonia (NH_4), and dissolved oxygen. We used these four variables to perform the CCA with the most abundant and frequent phytoplankton taxa: *Limnothrix planctonica*, *Alkalinema pantanalense*, *Leptolyngbya* sp., *Closterium acutum*, *Actinocyclus* sp., *Aulacoseira granulata*, *Pinullaria* sp., *Placoneis* sp., *Ulnaria* sp., and *Surirella guatimalensis*.

The axes 1 and 2 accounted for 96.03 % of the variance (axis 1: 81.47 %; axis 2: 14.56 %). We evaluated the significance of the ordination axes and the environmental indicators using the Monte Carlo permutation test (999 randomizations).

During the study period, two environmental factors greatly influenced the species distribution: suspended solids and ammonia. Suspended solids strongly influenced the abundance of *Leptolyngbya* sp. and *Aulacoseira granulata*, with *A. granulata* being more abundant in November. *Limnothrix planctonica* and *Alkalinema pantanalense* showed ammonia as the determining factor and occurred in greater densities in June and July, a time when the suspended solids were lower (Fig. 8).

Discussion

Concerning the physicochemical parameters, the Amazon River presents typical whitewater river characteristics: near-neutral pH, turbid waters rich in dissolved and suspended sediments, electrical conductivity between 40-100 μS.cm^{-1}, and low transparency (Sioli 1984; Junk *et al*. 2011).

The qualitative analysis clearly shows the great richness of species encountered in the intake point (S = 180). This inventory may guide the drinking water treatment management in the case of need to identify causes (precursors) of taste and odor compounds, since the predominant species in the area may not necessarily be the main source of the odor (Otten *et al*. 2016; Chong *et al*. 2018; Watson & Jüttner 2019). Besides, the qualitative

Table 3. Amazon River phytoplankton average biovolume in the study area CYAN – Cyanobacteria; CHLO – Chlorophyta; CHAR– Charophyta; BACI – Bacillariophyta; EUGL – Euglenophyta; GS – Geometric Shape; AB– Average Biovolume (μm^3).

Division	Taxon	GS	AB (μm^3)
CYAN	*Limnothrix planctonica*	Cylinder	219.71
CYAN	*Alkalinema pantanalense*	Cylinder	99.06
CYAN	*Leptolyngbya* sp.	Cylinder	73.43
CYAN	*Pseudanabaena* sp.	Cylinder	240.18
CYAN	*Anabaena* sp.	Cylinder	2041.99
CYAN	*Dolichospermum* sp.	Cylinder	4662.17
CYAN	*Geitlerinema_splendidum*	Cylinder	8661.33
CYAN	*Cephalothrix* sp.	Cylinder	10458.16
CYAN	*Raphidiopsis* sp.	Cylinder	91.08
CYAN	Ciano sp.	Cylinder	920.39
CHLO	*Actinastrum* sp.	Cylinder + 2 Cones	78.3
CHLO	*Acutodesmus* sp.	Cylinder + 2 Cones	375.5
CHLO	*Ankistrodesmus* sp.	Cylinder + 2 Cones	398
CHLO	*Desmodesmus communis*	Spheroid	246.2
CHLO	*Lacunastrum* sp.	Cylinder	1780
CHLO	*Nephrocytium* sp.	Ellipsoid	2200
CHLO	*Volvox* sp.	Sphere	900
CHLO	*Eudorina elegans*	Sphere	932
CHLO	*Mucidosphaerium pulchellum*	Sphere	310.9
CHLO	*Mougeotia* sp.	Cylinder	2433.46
CHLO	*Staurastrum quadrinotatum*	2 Truncated Cones	764
CHLO	*Staurastrum leptocladum*	2 Truncated Cones	1029.62
CHLO	*Scenedesmus acuminatus*	Cylinder + 2 Cones	375
CHAR	*Closterium acutum*	2 Cones	1800
CHAR	*Closterium gracile*	2 Cones	200
CHAR	*Closterium* sp.	2 Cones	4500
CHAR	*Closterium* sp.	2 Cones	3800
CHAR	*Closterium setaceum*	2 Cones	2620
CHAR	*Desmidium bailey*	Cylinder	11471.55
BACI	*Actinocyclus* sp.	Cylinder	4200
BACI	*Aulacoseira granulata*	Cylinder	8452.63
BACI	*Eunotia flexuosa*	Sickle-shaped Prism	316.47
BACI	*Fragillaria* sp.	Cuboid	397.5
BACI	*Gyrosigma* sp.	Parallelepiped	1500
BACI	*Pinullaria* sp.	Rectangular prism	7900
BACI	*Placoneis* sp.	Elliptic prism	269.53
BACI	*Ulnaria* sp.	Cuboid	400
BACI	*Urosolenia longiseta*	Cylinder	92.15
BACI	*Iconella obtusiuscula*	Elliptic prism	7500
BACI	*Iconella grunowii*	Elliptic prism	4000
BACI	*Iconella guatimalensis*	Elliptic prism	5500
BACI	*Iconella linearis*	Elliptic prism	4800
BACI	*Tabellaria* sp.	Cuboid	153.20
EUGL	*Phacus* sp.	Elliptic prism	1852

CYAN – Cyanobacteria; CHLO – Chlorophyta; CHAR– Charophyta; BACI – Bacillariophyta; EUGL – Euglenophyta; GS – Geometric Shape; AB– Average Biovolume (μm^3).

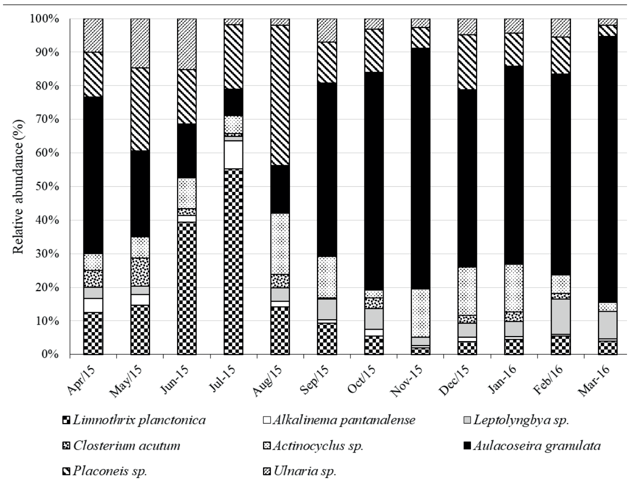

Figure 6. Abundant and dominant species at Macapá water intake point.

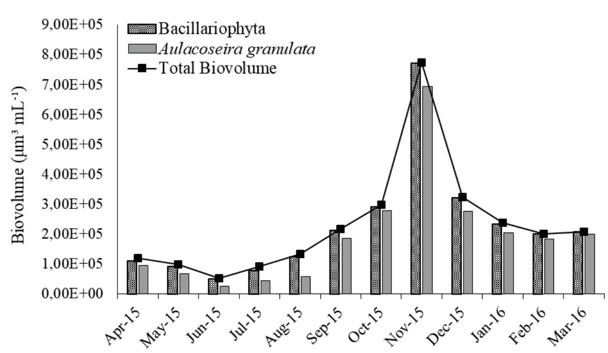

Figure 7. Total biovolume per month, and the contribution of Bacillariophyta and *Aulacoseira granulata*.

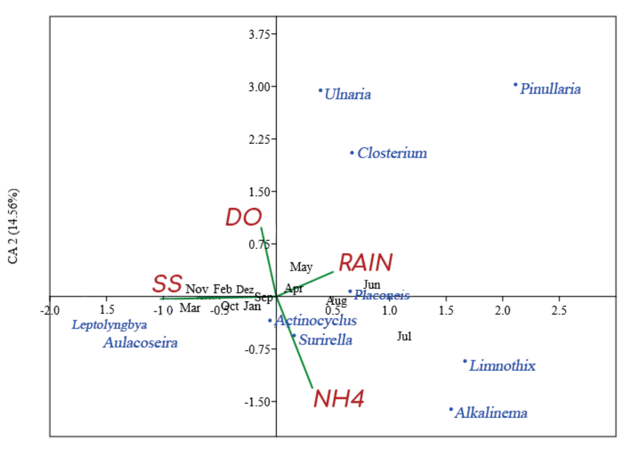

Figure 8. CCA ordination diagram (axes 1 and 2) applied to the matrix of selected biotic and abiotic variables. SS - Suspended solids; DO - Dissolved Oxygen; NH4 - Ammonia; RAIN - Rainfall; JAN - January; FEB - February; MAR - March; APR - April; MAY - May; JUN - June; JUL- July; AUG - August; SEP - September; OCT - October; NOV - November; DEC - December; Lepto_sp. - *Leptolyngbya* sp.; Aula_gra - *Aulacoseira granulata*; Acti_sp. - *Actinocyclus* sp .; Sur_guat - *Surirella guatimalensis*; Plac_sp. - *Placoneis* sp .; Alka_pant – *Alkalinema pantanalense*.

analysis will improve the knowledge of phytoplankton species in the Amazon River.

The quantitative analysis, on the other hand, does not consider all the species but detects the abundant and dominant species. This information is essential when considering problems like cyanotoxin production and filter clogging. The quantitative analysis shows that the Bacillariophyta and Cyanobacteria present the highest densities in the study area. *Aulacoseira granulata* (diatom) and *Limnothrix planctonica* (cyanobacteria) dominate the phytoplankton community in the area due to their body shape and physiological aspects greatly adapted to this turbulent and turbid environment (Reynolds *et al*. 1994; Nishimura *et al*. 2015; Oliveira *et al*. 2019a).

Aulacoseira granulata and *Limnothrix planctonica* are adapted to water column mixing conditions in shallow waters or mixed layers of 2-3m in thickness (Reynolds *et al*. 2002; Padisák *et al*. 2009; Brasil & Huszar 2011). These conditions match the Amazon River characteristics, as it is turbulent and has no stratification (Sioli 1984). In the intake zone, all depths can be considered within the vertical mixing zone (approximately 3m) all over the year (Junk *et al*. 2014).

Another common feature that favors the dominance of *A. granulata* and *L. planctonica* is their filamentous shape, which implies that these taxa have a relatively high surface area. It makes them good light receptors adapted to grow in environments with low light penetration, such as the Amazon River (Naselli-Flores & Barone 2007; Brasil & Huszar 2011; Nishimura *et al*. 2015; Oliveira *et al*. 2019a).

Concerning the water treatment and supply, *Aulacoseira granulata* is one of the producers of fishy, rancid, oily, grassy, or cucumber odors (AWWA 2010; Watson & Jüttner 2019). *A. granulata* is also problematic regarding coagulation, flocculation, and filtration in the water treatment process (Joh *et al*. 2011). Water treatment processes do not efficiently remove this species due to its long cylindrical shape, high surface to volume ratio ($S.V^{-1}$), extensive superficial area, and higher surface contact with the surrounding media, which are all related to physical buoyancy or difficulties in settling (Padisák *et al*. 2003; Brasil & Huszar 2011; Joh *et al*. 2011). Besides, this species also clogs the sand filters, leading to a need for repeated backwashing, thus limiting the production of clean water (Joh *et al*. 2011).

Limnothrix planctonica may produce the microcystin and limnothrixin toxins (Furtado *et al*. 2009; Bernard *et al*. 2011; Humpage *et al*. 2012; Whan 2015). *L. planctonica* strains were already isolated from the study area, but such strains showed no potential for microcystin production (Oliveira *et al*. 2019b). However, another study detected for the first time the presence of microcystin-LR in the Amazon River, at the same site, being *L. planctonica* the main suspect to have produced the toxin (Oliveira *et al*. 2019a).

Although the counting results show that the greatest densities belong to the groups Bacillariophyta and

Cyanobacteria, the biovolume analysis reveals that the phytoplankton in the study area is primarily composed of diatoms, especially by the species *Aulacoseira granulata*. Diatoms constitute a relevant group in terms of algal biomass in the Amazon region (Moreira-Filho *et al*. 1974; Paiva *et al*. 2006; Monteiro *et al*. 2009; Silva *et al*. 2018).

The canonical correspondence analysis shows that suspended solids affect the composition of the phytoplankton community. In this respect, *Aulacoseira granulata* and *Leptolyngbya* sp. have their abundance associated with the months of lower water transparency, while *Limnothrix planctonica* and *Alkalinema pantanalense* are at the opposite end indicating a relationship with greater water transparency. These four species are adapted to low light environments, such as the Amazon River. However, in the trimester June-August, there is an increase in the Amazon water transparency reaching 32cm, which is still a dark environment although much better for photoautotrophs. A study on *Limnothrix* growth at different light intensities (0, 80, 160, 400, 560 µE m2 s^{-1}) showed an increase in cell concentrations under all light intensity, even without light, with glucose addition. The highest cell growth occurred at an intermediate light intensity (160 µE m2s^{-1}) (Daniels 2016). In the study area, the *L. planctonica* population probably uses light most efficiently at the strength that it occurred from June to August.

As for nutrients, CCA associates *L. planctonica* and *Alkalinema pantanalense* with ammonia, which is the preferred nitrogen source of cyanobacteria (Oliver & Ganf 2000; Grego *et al*. 2004; Bastos *et al*. 2005; Ceballos *et al*. 2006).

The present study consists of qualitative and quantitative research of the phytoplankton community in the catchment area for the water supply of Macapá municipality. The quantitative analysis shows that, in the evaluated environment, two species stand out in terms of density and relative abundance: *Aulacoseira granulata* and *Limnothrix planctonica*. Nevertheless, the biovolume values show the contribution of *A. granulata* as being the most representative in the study area. The paper also shows the environmental influence on phytoplankton species. The suspended solids are a natural condition that helps to control the phytoplankton density. On the other hand, ammonia is a common nutrient in domestic sewage that contributes to the phytoplankton increase and may be reduced with better investment in sanitation. These results demonstrate the biological and sanitary aspects of the species with the highest density and biomass (*A. granulata* and *L. planctonica*), which are more likely to influence water treatment in Macapá city.

Acknowledgements

We thank the Companhia de Água e Esgoto do Amapá, the Governo do Estado do Amapá, the Exército Brasileiro, the IBGE, and the Laboratório de Química e Saneamento da UNIFAP. We also thank Eleonora Cunha, Dinaldo Miranda and Sérgio Kléber for technical support. This study was translated and published with resources from the Support Program for National and International Academic Publications of the Universidade do Estado do Amapá.

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